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Riparian Habitat Utilization By
Western toads (Bufo boreas) Spotted
Frogs (Rana pretiosa) On The Targhee
National Forest

FINAL REPORT FOR RESEARCH AGREEMENT
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FINAL RE

RIPARIAN HABITAT UTILIZATION BY WESTERN TOADS (*Bufo boreas*) AND SPOTTED FROGS (*Rana pretiosa*) ON THE TARGHEE NATIONAL FOREST

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INTRODUCTION

This final report presents the results of fieldwork we conducted during 1993 to determine movement patterns and riparian microhabitat utilization by western toads (*Bufo boreas*) and spotted frogs (*Rana pretiosa*) on the Targhee National Forest. It completes the requirements of contract #INT-93780-CCSA between Idaho State University and the Intermountain Research Station of the U.S.D.A. Forest Service. We describe the study sites, our methodology, and the movements and habitat use of these animals.

Objectives

A general objective of our research is to determine the habitat relationships of spotted frogs and western toads in the Greater Yellowstone Ecosystem (GYE). This research will form the basis for developing habitat models for these species which, when used with a Geographic Information System (GIS) database, should improve our ability to predict amphibian distributions in the GYE. The specific objective of this study was to determine riparian habitat utilization by western toads and spotted frogs on the Targhee National Forest (TNF). Specific questions were: (1) After breeding, how far do adults travel from the pond? (2) What is the difference in the distance traveled by toads and frogs, and by males and females? (3) After breeding, how do toads and frogs use riparian habitats for foraging? and (4) What environmental factors influence their choice of microhabitat sites?

Significance

Numerous populations of true frogs and toads (families Ranidae and Bufonidae, respectively) appear to be declining in North America (Corn and Fogelman 1984; Beiswenger 1986; Freda and Dunson 1986; McAllister and Leonard 1990; Wake and Morowitz 1990; Wyman 1990; Wake 1991). Although amphibian populations can experience wide fluctuations (Pechmann *et al.* 1991; Wissinger and Whiteman 1992), the global scale at which these declines seem to be occurring has led many in the herpetological community to suspect that some anthropogenic cause(s) may be contributing to these declines (Haynes and Jennings 1986; Weygoldt 1989; Bissonette and Larson 1991; Carey 1993). These apparent declines have concerned many biologists for several reasons. For example, amphibians may be more important components of ecosystems than are often recognized (Burton and Likens 1975; Vitt *et al.* 1990; Gibbons and Semlitsch 1991; Scott and Seigel 1992). In addition, because these

need a greater understanding of the ecology of these animals, especially their habitat relationships.

Approach

To determine the movements and habitat use of these animals, we analyzed their movements with respect to the distribution of habitats, with a combination of radio telemetry, a global positioning system (GPS), and a Geographic Information System (GIS). To determine habitat selection by western toads and spotted frogs, we compared habitats used by these animals to those that were available to them. Circular statistics were used to analyze the significance of animal movements with respect to habitat patterns, and multivariate analysis was used to determine which microhabitat features were most important to these frogs and toads. We used thermocouples to measure the environmental conditions of each microsite used by a frog or toad, and data loggers to continuously monitor general environmental conditions at one of the study sites.

METHODS

Study Sites

We selected the Targhee National Forest (TNF) as the study area for a number of reasons. First, because the TNF constitutes much of the western portion of the GYE, this study will be relevant to other amphibian studies occurring elsewhere in the GYE and will provide a basis for developing habitat models for these species in the GYE. Second, we know that spotted frogs and western toads breed on the Forest, and are most abundant on the Island Park and Ashton Districts of the TNF (Clark *et al.* 1993). We selected the Island Park District because of its relatively easy access diversity of habitats. In addition, we have a good working relationship with the personnel on this District, and they want to know more about the amphibians that occur on the TNF, especially spotted frogs and western toads.

We collected data at five different study sites on the Island Park District: (1) Lucky Dog Creek, (2) Moose Creek, (3) Stamp Meadows, (4) Blind Creek, and (5) Sheridan Creek. Movement and habitat data were collected at all but the Blind Creek site. Together, these five sites represent an east-to-west transect across the northern half of the District (Figure 1), and allowed us to compare areas with different topography and habitats (Table 1). The topography and habitat conditions differed among these sites, reflecting the differences in the geology and soils among the sites.

For several reasons why we did not track all 13 toads for the entire season. For example, one of these toads (#24; not shown in Figure 2) was never relocated after release and we suspect the transmitter failed. We were able to track toad #21 for only four days; we suspect it was eaten by a sandhill crane (*Grus canadensis*). And, we did not find some toads (*e.g.,* #50 and #51) until later in the season, and these later escaped from their transmitter.

We relocated each individual about every 2-3 days. Each time we relocated a telemetered animal, we flagged the site and recorded data for a number of microhabitat variables (see Habitat/Environmental Conditions below). We weighed each animal every 7-10 days as an indicator of its general health. We then returned at a later time to record the location of each position with the GPS. Afterwards, in the laboratory, all of these positions were differentially corrected and plotted to produce a map of their movements. These data were then imported into PC ARC/INFO for further analysis of movements and habitat use.

Effects of the radio transmitters on toads and frogs. Ideally, to collect the most accurate and reliable data, a transmitter should be attached to an animal in such a way that it does not affect the animal's normal behavior or physiology. The actual effect an attached transmitter has on an animal is difficult to test, because effective controls are difficult to obtain. Consequently, we have used laboratory observations and changes in weight gain or loss as indicators of the effect of transmitters.

The transmitter and harness on individual animals varied, and affected frogs to a greater degree than toads. The belt harness tended to cut the skin of frogs after about one month of attachment. Debra Patla (ISU, graduate student, *pers. comm.*), observed the same problem with spotted frogs in Yellowstone National Park. The effect that this skin damage might have on the behavior of frogs is not known, but improvements on this design are needed for movement studies of frogs that extend beyond one month.

The effect of this harness design on toads was mixed, but it seemed to affect toads less than frogs. Laboratory experiments during the winter of 1993 indicated that this design did not affect the behavior of captive toads. During this field study, some individual toads traveled considerable distances through rough terrain, and all telemetered toads successfully utilized small, cramped microsites (*e.g.,* underground burrows, cavities in logs), apparently without a problem. In addition, most gained weight, or lost a minimal amount of weight during the summer (Figure 3), indicating that they foraged successfully.

One of the toads (#25) showed no signs of effect from the transmitter/harness, and two toads (#31 and #50) minor skin abrasions. They gained or generally maintained weight (Figure 3), the skin abrasions healed well, and we collected a relatively large amount of data on the

patches, one in the smallest patches and three in the largest patches (Figure 5). During the collection of these data, we added or changed some of the map boundaries to improve the homogeneity of the patches. Because we often observed toads using underground burrows, we also recorded an index of burrow density in each patch by counting the number of burrows within one meter on either side of each transect.

To compare the macrohabitats used by these animals to the macrohabitats available, we distributed a number of random points on the cover map equal to the number of animal locations. To determine if macrohabitat selection occurred, we compared the distance of these points and of animal locations to the edges of patches, and we compared the habitats of animal locations ("used" habitats) to that of randomly selected habitats ("available" habitats).

Microhabitat. Each time we relocated a toad or frog, we quantified the characteristics of that microhabitat (Table 3). To compare the frequencies and characteristics of the microhabitats used by these animals, to those available around that microsite, we sampled microhabitat at two different scales, each centered around the animal's location: (1) in a 0.25 m^2 area, and (2) in a 79 m^2 (5 m radius) area (Figure 6). We measured three levels of habitat (ground cover, shrub cover, and canopy cover) at each scale, and expressed the amount of each as a percent of the total area. Because these three levels of cover overlap, and each may be important to the animal, each was measured separately. When summed, the three together may produce a total coverage of greater than 100 percent.

We used a 0.5*x*0.5 m quadrat to quantify the microhabitat features within the 0.25 m^2 area surrounding each animal. The quadrat was centered around the animal's location and subdivided into 25 squares, each 0.1*x*0.1 m, so that we could measure percent cover to the nearest 2 percent. We also measured the distance to the single closest cover from the animal's location, and noted its size and type. If the animal was already well hidden in some type of cover, then we recorded the distance as 0 m. These methods are similar to those used for measuring microhabitats of small forest mammals (Dueser and Shugart 1979) and snakes (Reinert 1984).

We collected data for the second scale of microhabitat by measuring the amount of each cover type that intersected four transects. Each transect was 5 m long, radiated from the animal's location, and was placed along one of the four cardinal directions. The amount of ground and shrub cover was read to the nearest centimeter along each transect. Percent canopy cover was measured at the animal's location with a concave spherical densiometer. The amount of cover for each transect was totaled and then expressed as a percent of that transect. The results for each cover type for all four transects then were averaged to produce a single

Habitat Selection. To determine if animals are selecting certain habitats, it must be shown that the animals are using these habitats in a proportion greater than they are available. To determine macrohabitat selection, we used logistic regression models (Whittam and Siegel-Causey 1981) to model the macrohabitats used by individuals compared to the randomly selected macrohabitats. We included into these models data collected from the 200 m transects, for all cover types, to identify which habitat categories were significantly different from used sites and randomly selected points. Using the cover map and χ^2, we compared the frequencies of used and randomly selected macrohabitats for those habitat categories shown to be important by logistic regression analysis.

To determine microhabitat selection, we compared differences in the percent cover of habitat categories between the two scales of microhabitat. We considered the smaller scale of (0.25 m^2) to be the habitat "used" by an animal, and the larger scale (79 m^2) to be the habitat "available" to it. Because data for these variables were expressed as percent cover, they were arcsine transformed to meet the statistical assumption of normality (Zar 1984). These transformed values also were used to produce histograms of distribution of the data. We used several statistical methods to analyze the microhabitats used by these animals, and to test for selection. These methods included MANOVA, principal components analysis, and multiple regression. Because the data from the two scales of measurement had unequal variances, we used the Mann-Whitney test to test for apparent differences between these data sets.

For each scale of microhabitat for each of toads #22, 25, 31, 46, and 50, we used principal components analysis (Dunteman 1989; Morrison 1990) to model habitat use, and to identify which habitat variables explained most of the variation in each data set. We used the method described by Jolliffe (1986) to select this subset of variables. This method assigned a rank number, lambda value, and proportion of variance to each habitat variable. We pooled these data for five toads and used MANOVA to test if certain habitat variables consistently explained more of the variation.

Although methods to compute resource selection functions by animals have been recently developed (Manly *et al.* 1993), we were unable to apply these methods to our data. Because aspects of the available habitat in this study (*i.e.*, the larger scale of microhabitat) were temporally changing (L.D. MacDonald, *pers. comm.*), special modifications of resource functions were needed to accurately compute the probabilities for selection. Arthur and MacDonald (*in prep.*) are developing a selection probability function for situations where the available habitat changes, but it was developed for variations in a single habitat variable. Because our data sets contain six habitat variables, this method will need to be further modified before we can use it.

I. Western Toads

Occurrence of Toads at Study Sites

We found a large number of toads breeding in the Stamp Meadows pond and only a few at Sheridan Creek later in the season (Table 4A). We did not find toads at any of the other five study sites, which was consistent with the observations of Clark *et al.* (1993). Because we did not find any toads sufficiently large to telemeter at Sheridan Creek until late August, all of the movement and habitat selection data of western toads in this report were collected on toads at the Stamp Meadows site.

Numbers of Animals

We marked and measured 51 toads in or near the Stamp Meadows pond. None of these toads weighed less than 30 g (Table 4A). We marked a total of six toads at the Sheridan Creek site in August and September. Earlier, in late June, we found a juvenile toad in the pond east of the creek, but we did not mark it because its left eye was injured, and we did not want to increase its stress. On August 28, we found eight toads under a large (about 75x55x15 cm) rock lying on the north bank of Sheridan Creek, replicating the observation made by Clark *et al.* (1993) at the same site and at a similar time as in 1992. We caught and marked three of these toads (the others escaped), and telemetered one of these three toads. Later in September and October we telemetered three more toads near this site.

Movements

At Stamp Meadows, male and female toads displayed significantly different patterns of movement (Figure 8). All three telemetered males never left the pond area, whereas two of the three females (#25 and #31) left the pond after breeding and traveled considerable distances (1.3 km and 2.5 km, respectively; Figure 9). Although they dispersed in generally opposite directions, their patterns of movement were significantly ($p<0.005$) linear.

The rates of movement of toads #25 and #31 varied with the season and the macrohabitat. When dispersing, these two toads displayed a high rate of movement: up to 330 m/day. In contrast, the foraging movements of these and other toads ranged from 0-50 m/day.

The movements of toad #31 were significantly oriented with respect to a growth of shrub that grew in a linearly shaped patch, whereas those of toad #50 were oriented to scattered shrub and debris cover that occurred under the canopy of mature conifers.

Microhabitat Use

At Stamp Meadows, we commonly found toads near or at the entrance of an underground burrow. In fact, underground burrows (*e.g.*, gopher hole or burrow into a large slashpile) were the most commonly used microsite (Figure 16). Some microsites (*e.g.*, shrub and litter) provided a combination of two cover types, and presumably provided both shade and a moist substrate. Many times we found toads basking in the midday sun, only a small distance from the nearest cover (within two meters, Figure 17). We assumed this behavior to be for thermoregulatory purposes. Some toads seemed to use and return to one or a few microsites. We found that toads #22, #25, and #31 consistently used two or three microsites within their foraging areas, and that they would return to this microsite after spending few or several days visiting other microsites.

Stamp Meadows toads used similar microsites in different habitats. In the microhabitats used by the five toads, there was no overall individual effect ($F_{28,214} = 1.3056$, $p = 0.149$) for the smaller microhabitat scale (0.25 m^2), but there was a significant individual effect ($F_{24,214} = 2.4208$, $p = 0.0004$) for the larger scale (79 m^2). For toads #22, 25, 31, and 46, there was a significant difference in the percent shrub cover between the two scales of measurements (Figure 18). The 79 m^2 area had significantly more shrub cover than the 0.25 m^2 area. The lack of differences among the two scales of microhabitat for toad #50 was probably related to its different movement behavior. Unlike the other five toads, toad #50 stayed within the same general habitat and within 17 m of the center of its home range.

No trends were apparent from principal components analysis. We attribute this lack of a trend(s) to the small data sets.

Sheridan Creek toads primarily used underground burrows at the base of a willow bush, fir tree, or under a log. Three of the four toads found a burrow within a meter of a small flowing creek and remained there for hibernation.

Environmental Conditions and Microhabitat Use

There were weak relationships between microsite temperatures, microhabitat structure, and weather conditions. There was no overall time effect ($F_{14,118} = 0.8504$, p = 0.614),

By mid June, most of the frog eggs hatched and we observed large numbers of tadpoles in each respective pond, with the exception of Blind Creek. Nearly all the tadpoles at this site had hatched by early June, but they had not yet left the pooled jelly coats of the egg mass. A large thunderstorm passed through the area on June 11 and washed out a portion of the beaver dam, dropping the water level enough to leave the tadpoles stranded on a mat of *Carex* and mud. The night-time freezing temperatures that followed the storm froze the stranded tadpoles.

We began observing more adult spotted frogs by mid-season. During early July, we observed at least six adult frogs in the Moose Creek pond, but all of them were thin and lethargic. Within two weeks, these six died, as had scores of tadpoles that we observed floating in the pond. Mixed with these spotted frog tadpoles were some dead chorus frog (*Pseudacris triseriata*) tadpoles. We were unable to determine the causes of these deaths.

In August, we observed metamorphs (*i.e.,* newly transformed tadpoles) in or near the Moose Creek, Lucky Dog, and Sheridan Creek breeding ponds. The Sheridan Creek pond contained the largest number of metamorphs. Although time prevented us from conducting a thorough count, on September 8 we clipped 36 individuals in about 15 minutes. Most of these metamorphs had moved from the breeding pond to Sheridan Creek (~10 m distance) and were gathered along the banks of the creek. Some were trapped in the deep hoof prints of cattle, some were hiding in *Carex*, and others were hiding on the bottoms of small, still pools.

Movements

We telemetered only one frog during the summer. This frog was telemetered in a small (0.6 ha) pond about 45 m from Moose Creek. During the month we tracked her, she traveled throughout this small pond, but never left it. Her movements were not significantly different from random (Figure 19). On July 30, four weeks after we began tracking her and a week after we last located her, we found that she had been eaten by a garter snake (*Thamnophis elegans*). We found more large frogs later in the season and telemetered three in September (Figure 2). None moved more than 200 m from each of their release site.

Macrohabitat Use

The Moose Creek pond was dominated by cattail (*Typha*) and sedges (*i.e., Carex*), and supported a growth of willow around its perimeter. The telemetered frog in this pond utilized all of these habitats, and often sought hiding places among the cattails.

DISCUSSION

I. Western Toads

Occurrence and Numbers of Animals

Based upon the observations of Clark *et al.* (1993), we expected to find western toads at only two of the five study sites. However, the occurrence of breeding toads at the Stamp Meadows site is a new observation.

The number of toads we marked at Stamp Meadows might seem like a comparatively small number of animals, but to our knowledge it is the single largest population of adult toads in the GYE. Interestingly, none of the toads we measured, for the entire season, were less than 30 g. This indicates either that juvenile toads are very difficult to find, or that because of the recent six year drought, toads may not have successfully reproduced for several years. Because Stamp Meadows pond dries each year (Robbin Jenkins, Forester, Targhee National forest, *pers. comm.*), and because variations in annual weather conditions (*e.g.,* a late spring) may delay the time of breeding, toads at this site may successfully reproduce only every few years or less. Any disturbance or stress factor that worsens this situation may reduce the chances of this population persisting.

Movements

Some of the observations we made of western toads at the Stamp Meadows study site surprised us. We did not expect them to travel so far from the pond, nor did we expect them to remain out of water for months at a time. To our knowledge, there are no other records of *Bufo boreas* traveling 2.5 km from its breeding site over the type of terrain that occurs in the Stamp Meadows area. There are a number of examples where this or a related species have traveled up to 1 km from its breeding site or during an annual migration. For example, in Colorado, Campbell (1970) observed many *B. boreas* seasonally travel 900 m between a traditional breeding site and a communal hibernaculum. Similarly, Sinsch (1988, 1989) observed European toads (*B. bufo*) travel about 1 km between a traditional breeding pond and hibernaculum. We do not know if female toads that disperse so far from Stamp Meadows pond return to breed. If female western toads low breeding site fidelity similar to natterjack toads (*Bufo calamita*; Sinsch 1994), they may continue to travel until they find another body of water. However, in this situation, because the nearest suitable breeding site or permanent

However, because cutaneous evaporative water loss (EWL) is very high in amphibians (Shoemaker *et al.* 1992), and because EWL of Colorado toads increased directly with skin temperature, these toads also would need to remain near an area of greater cover for eventual retreat. Because underground burrows have an essentially saturated vapor density (Warren Porter, Univ. of Wisconsin, *pers. comm.*), these burrows may have been an suitable retreat site.

Even though humid retreat sites might have served to decrease EWL after basking, a large amount of water still may be lost during basking. For toads to maintain hydric homeostasis, they must periodically replenish body water. Colorado female toads that inhabited dry montane hillsides seemed to restrict their activity to near or within a burrow, then moved to water at night to rehydrate (Carey 1978). Because water was not available at the Stamp Meadows site, these toads remained out of water for most of the summer and must have replenished body water by another means. They may have replenished body water by absorbing water after a rain or morning dew. We observed swollen thighs and pelvic region on some toads after such wet periods, and we suspect they were storing water in subcutaneous lymphatic sacs (Duellman and Trueb 1986; Boutilier *et al.* 1992). The ability for toads to absorb water from the pelvic region of their ventral skin, and to move water from a saturated surface through cutaneous channels of their skin (Lillywhite and Licht 1974), may provide them with the means to replenish body water from periodically saturated terrestrial habitats.

Although toads selected a combination of open and shaded habitats, extremely open habitats (*e.g.*, clearcuts) may have been avoided by toads. These habitats may be too hot and dry for these wet-skinned ectotherms.

Environmental Conditions

Because the activity of many ectotherms is closely tied to their body temperatures, which is influenced by thermal and other physical aspects of their environment (Huey 1991; Peterson *et al.* 1993), we were surprised that different temperatures and weather conditions did not account for recognizable differences in the habitat use by the Stamp Meadows toads. We attribute this to the small sample sizes we collected for most of the toads, or because we may not have measured the appropriate temperature data to identify any expected differences. The body temperatures of ectotherms are affected by a number of physical processes (*e.g.*, radiation, conduction, convection, and evaporation). However, because shaded air temperatures are not a good indicator of toad body temperatures, the air temperatures recorded by the weather station at Stamp Meadows may not have allowed us to separate the day into time periods that reflect changes of thermal conditions that were significant to the toads.

Creek and Lucky Dog ponds during the summer. This was different from the behavior of a population of spotted frogs in Yellowstone National Park. Many of these frogs inhabited wet meadows within 100 m of a pond or stream during the summer (Turner 1960). Ray Clark (graduate student, ISU, *pers. comm.*) did not find any frogs more than about 20 m from a stream or pond on the TNF, although he did not search any wet meadows that were 100 m from a pond or stream. If the TNF is generally drier than Yellowstone National Park, then the movements of the frogs observed in this study may be typical of spotted frogs elsewhere on the TNF.

The apparent gathering of spotted frog metamorphs along the banks of Sheridan Creek in the fall may be have been a pre-dispersal behavior. We suspect that Sheridan Creek, both the riparian habitat and the creek itself, may be a significant dispersal corridor for these frogs, and in subsequent years we will search ponds downstream for any of these marked individuals.

Habitat Use and Selection

Rarely did we find a spotted frog <1 m from water and water was always a significant part of their habitat use. During most of the summer, we observed frogs using riparian habitats in or around a pond, where they sought refuge in the litter and sediments at the bottom of the pond. For example, the Moose Creek frog used a variety of habitats in that pond. We found it hiding among the cattails (*Typha*) in water as much as 36 cm deep, sitting within willows near the edge of the pond, and in the shallow pond edges basking in the sun. Because spotted frogs were so closely associated with water, they probably did not experience the environmental extremes experienced by western toads.

The combination of a permanent stream and a pond within 50 m of that stream provides important habitat for spotted frogs. During the summer we found most frogs in or around ponds, but later in the fall, they began appearing in or around nearby streams. For example, the telemetered frog at Moose Creek pond never left the pond during July, and on three separate searches of an ~800 m stretch of Moose Creek during that same time, we observed only one frog. Similar searches of Lucky Dog and Sheridan Creeks during summer gave similar results. When we repeated this search along Lucky Dog and Moose Creeks in September, we found eight frogs within one hour. In addition, the telemetered frog at Sheridan Creek left its pond a week after we telemetered it (September 5) and hibernated at the bottom of Sheridan Creek. These observations emphasize to us the importance of riparian habitat as seasonal movement corridors for these animals. Because spotted frogs seem to use traditional riparian areas for moving among breeding, foraging, and hibernation areas (Turner 1960), any

Western Toads. Western toads at the Stamp Meadows site traveled overland a considerable distance from the breeding pond and used a wide variety of forested habitats. Because of this, a greater variety of land uses may directly affect these animals, than would spotted frogs. When considering the apparent declines observed in this species in this area, we encourage land managers to incorporate the needs of these animals into land management plans.

We do not know if the movements and habitat use that we observed among toads at Stamp Meadows is typical of other populations of toads on the Forest, but given that other studies (*e.g.,* Campbell 1970; Sinsch 1989) have shown that toads travel up to 1 kilometer between traditional breeding sites and hibernacula, the behavior of toads at Stamp Meadows may not be unusual. If toads from other populations display similar movement patterns, then the configuration of macrohabitats on the forest could significantly influence the gene flow among populations and the general dynamics of metapopulations (Pulliam 1988; Sjogren 1991). For example, if a forested area that lies between a breeding pond and a traditional hibernaculum of toads is clearcut and becomes hot and dry for toads, this could interrupt their seasonal migrations and could endanger these toads. If a forested area lying between two breeding sites is clearcut, this could interrupt gene flow between these sites, and thus isolate these gene pools and may reduce the stability of both populations.

To better understand the movements of western toads, and the relationships between their habitat use and landscape patterns, we need more information on the microclimates they use and those that are available in different macrohabitats. We plan to use biophysical models (Bradford 1984) to measure thermal and hydric environments, and contrast the microclimates of sites used by toads under different macrohabitats. This information should help us understand better the influence of environmental conditions on the movements of these animals, their habitat selection, and should provide important microenvironmental data that will be applicable to other questions (*e.g.,* the movements and habitat use of small mammals). It also would begin an important database of microenvironmental conditions that are needed to complement the existing data of large scale environmental conditions (Bill Kirchhoff, GIS Coordinator, TNF, *pers. comm.*).

Spotted Frogs. From observations made in this study and those by Peterson *et al.* (1992) and Clark *et al.* (1993), spotted frogs appear to be successfully reproducing and maintaining viable populations on the Targhee National Forest and in much of the Greater Yellowstone Ecosystem. The combination of palustrine habitats near riverine habitats seems to be important to these animals, particularly for those that breed in small ponds.

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Table 1. Physical description and dominant vegetation of study sites.

Site	Location (UTM) (meters) Northing	Easting	Elev. (m)	Size of Pond (ha)	General Topography	Type of Riparian Habitat	Dominant Vegetation
Lucky Dog Creek	4925653	477628	1936	0.35	gentle, floodplain	palustrine near riverine	*Pinus, Salix, Typha, Carex*
Moose Creek	4925439	477201	1940	0.43	gentle, floodplain	palustrine near riverine	*Pinus, Salix, Typha, Carex*
Stamp Meadows	4929198	471362	1959	16.65	rolling	palustrine	*Populus, Salix, Pinus, Carex*
Blind Creek	4926539	451250	2004	0.4	gentle, floodplain	palustrine near riverine (active beaver pond)	*Salix, Populus, Carex*
Sheridan Creek	4926661	444967	2027	0.028	rolling	riverine w/ palustrine elements	*Pseudotsuga, Aibes, Salix, Alnus, Carex*

Table 3. Environmental conditions and habitat variables recorded at each relocation of a telemetered frog or toad. "Shrub cover" includes small (*i.e.*, $\leq$3 m aspen and conifer trees that provided groud cover similar to willow, alder, and other shrub species. These were small trees that supported live branches $\leq$0.5 m above the ground.

Habitat	Environmental Conditions
Ground cover:	Transmitter temperature
herbaceous	1 cm shaded air temperature
litter	Relative Humidity:
woody debris	microsite
bare soil	2 m above ground
rock	Weather conditions:
moss	wind velocity
water	wind direction
Shrub cover:	cloud cover
willow	
aspen	
conifer	
other shrubs	
Canopy cover:	
Distance to nearest hiding site	
Distance to water	
type of water source	
Number of logs in 5 m transects	
average log diameter	

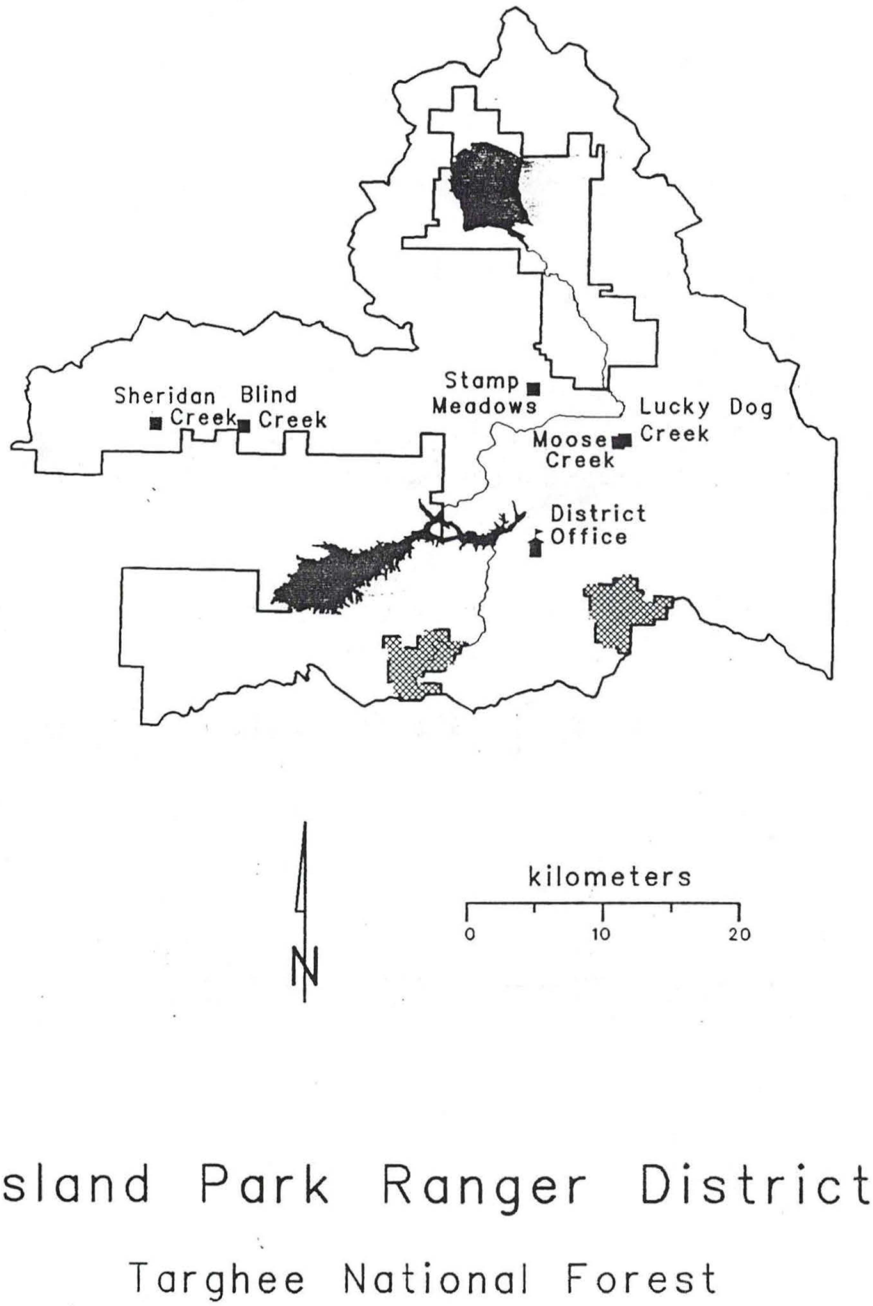


Figure 1. Location of 1993 study sites on Island Park Ranger District.

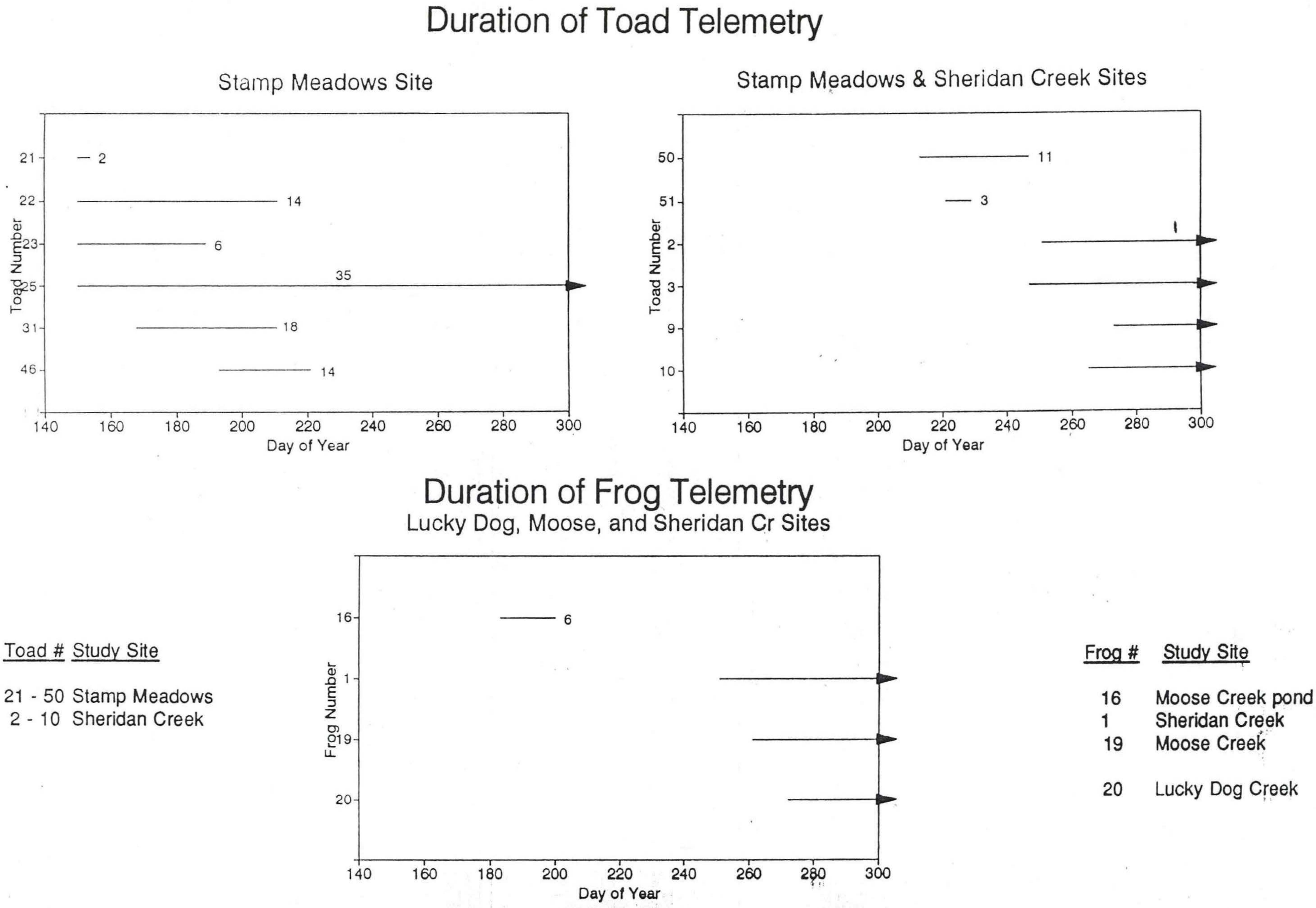


Figure 2. Length of time that different frogs and toads were telemetered during 1993. Toads #21, 22, 23, and 25 were telemetered beginning May 30 (day #150). Other toads were telemetered beginning later in the summer or fall. Frog #16 was telemetered beginning July 2 (day #183). Other frogs were telemetered beginning in September. Arrows extending beyond the right-hand border of graphs indicate those animals that were telemetered during winter. Numbers on bars = number of relocati

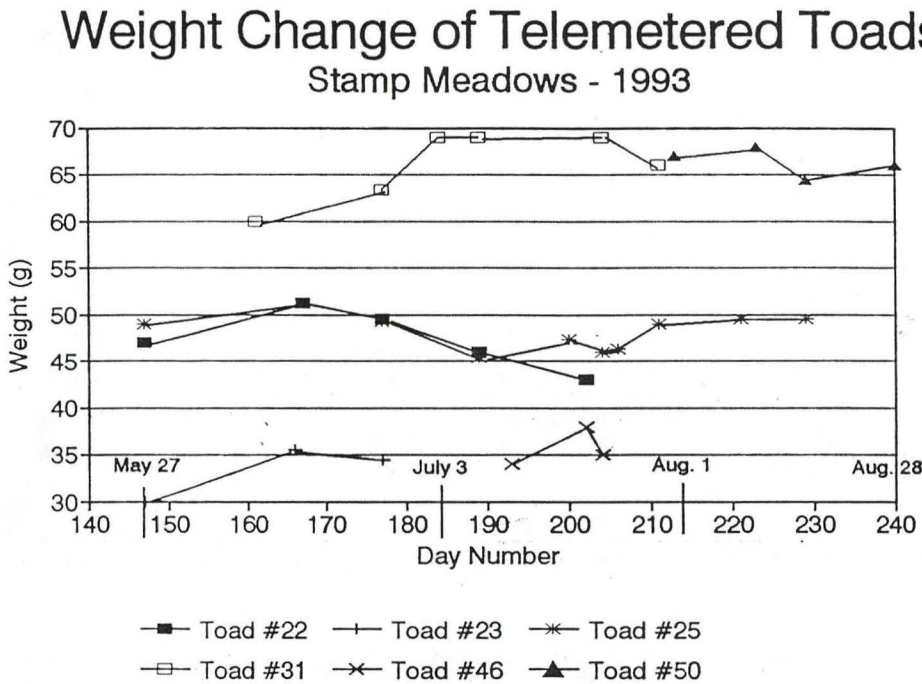


Figure 3. Weight changes of six telemetered toads at the Stamp Meadows site. Fluctuations in the weights of all toads may reflect normal periods dehydration during dry periods and rehydration after rains or heavy morning dew. Toads #22 and #46 may have displayed relatively more dramatic overall weight losses. Neither of these two toads left the pond area.

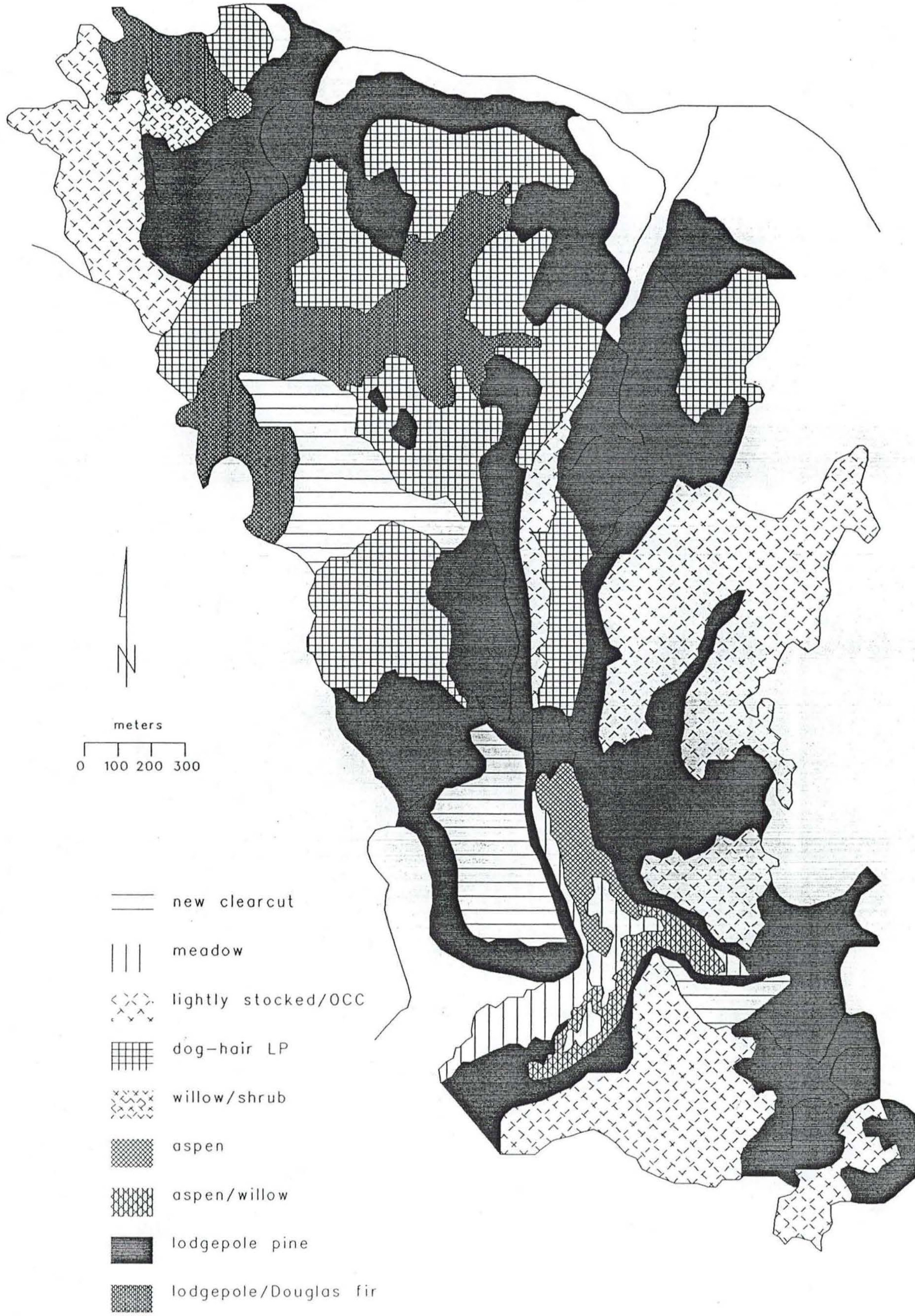


Figure 4. Cover map of macrohabitats at the Stamp Meadows study site. This map was digitized from stereographic aerial photos, then drawn with PC ARC/INFO. Stamp Meadows pond is near the bottom. The cover type "dog-hair LP" represents patches with dense growths of 3-4 m lodgepole pine trees; "lightly stocked/OCC" represents old clearcuts with relatively few sapling pine trees.

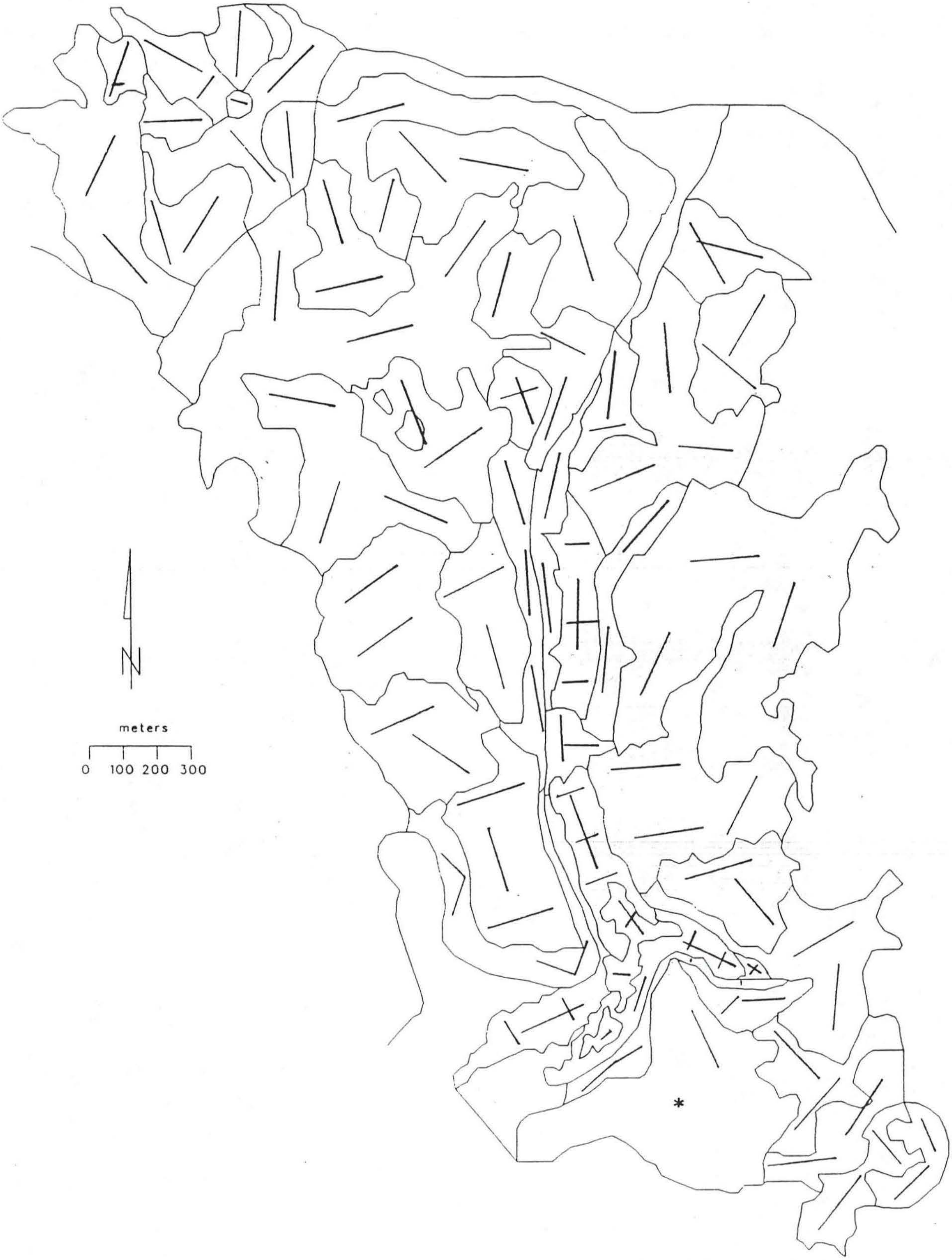


Figure 5. An outline of the macrohabitat map showing the number and placement of 200 m transects in each habitat patch. The asterisk (*) indicates a patch in which logging was occurring. The habitat for this patch was determined by a single 200 m transect and visual estimations.

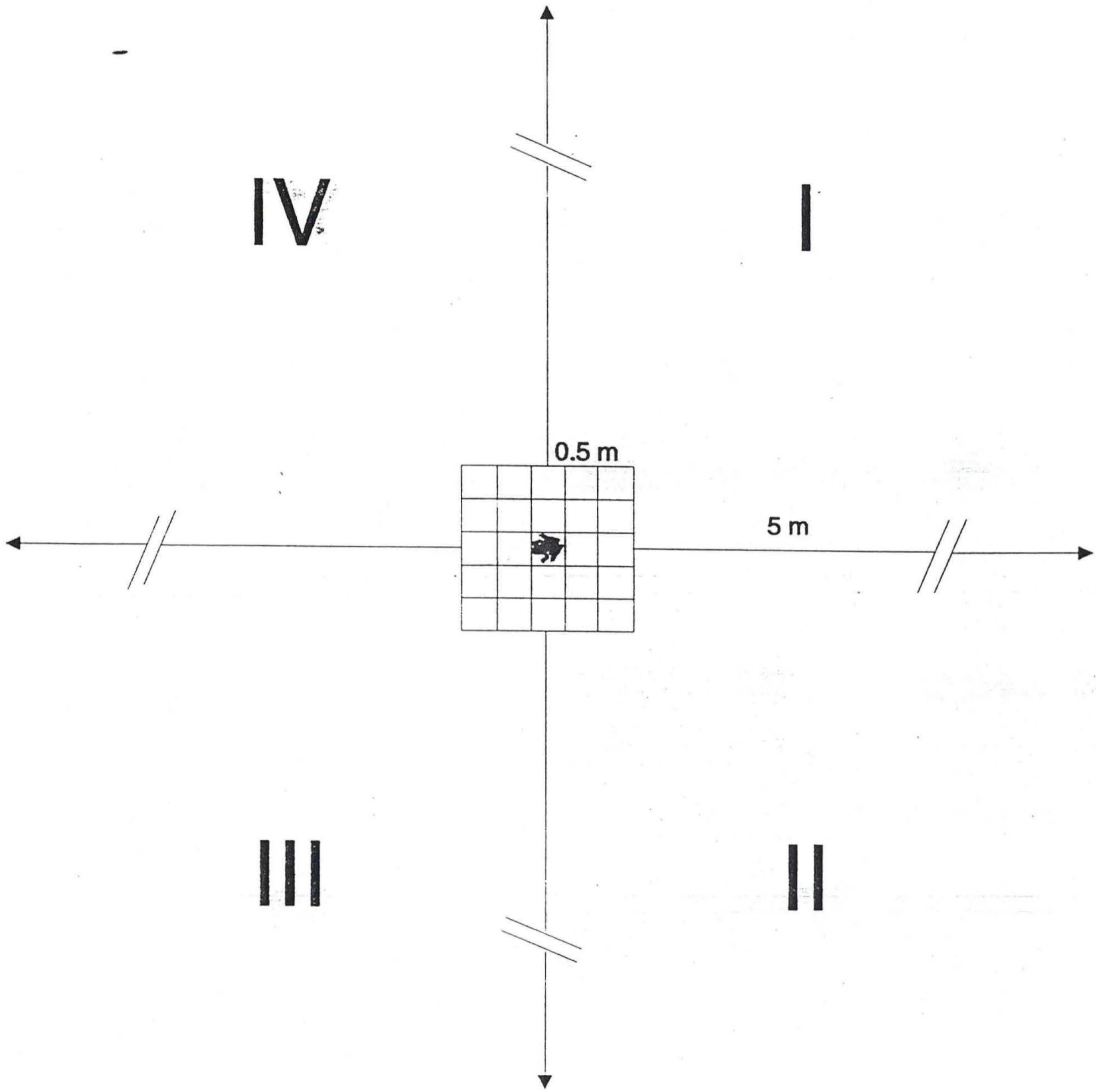


Figure 6. Our sampling method for measuring percent cover at the 0.25 m^2 and 79 m^2 scales of microhabitat. The central grid represents the 0.5*x*0.5 m quadrat for sampling 0.25 m^2 of habitat, and is nested within the four 5 m transects (represented by the four arrows). Nearest hiding cover measurements were made in each of the four numbered quadrants.

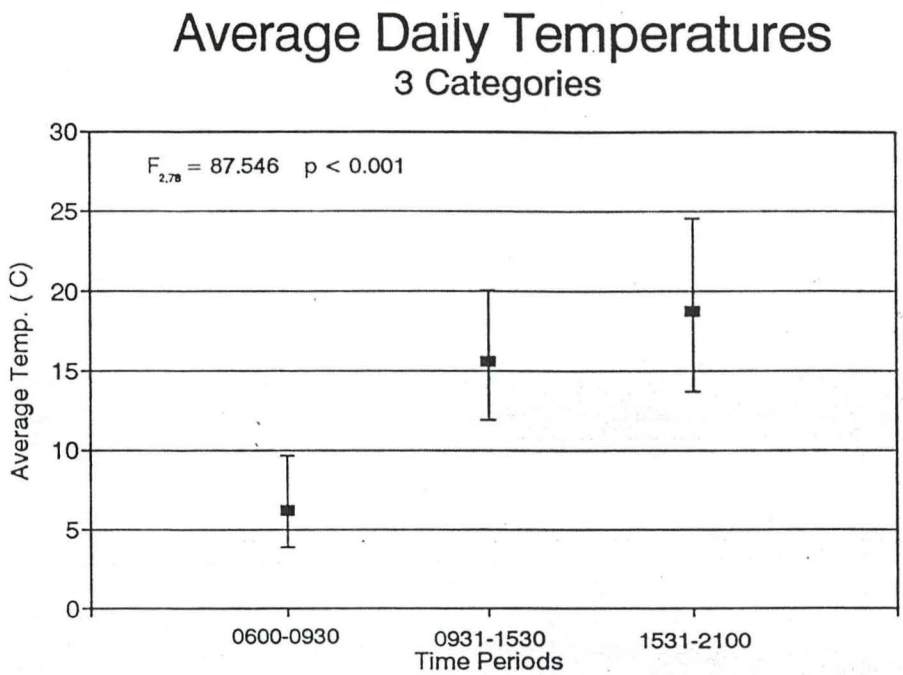


Figure 7. Average daily temperatures for three time periods. Data were collected from a weather station at the Stamp Meadows study site.

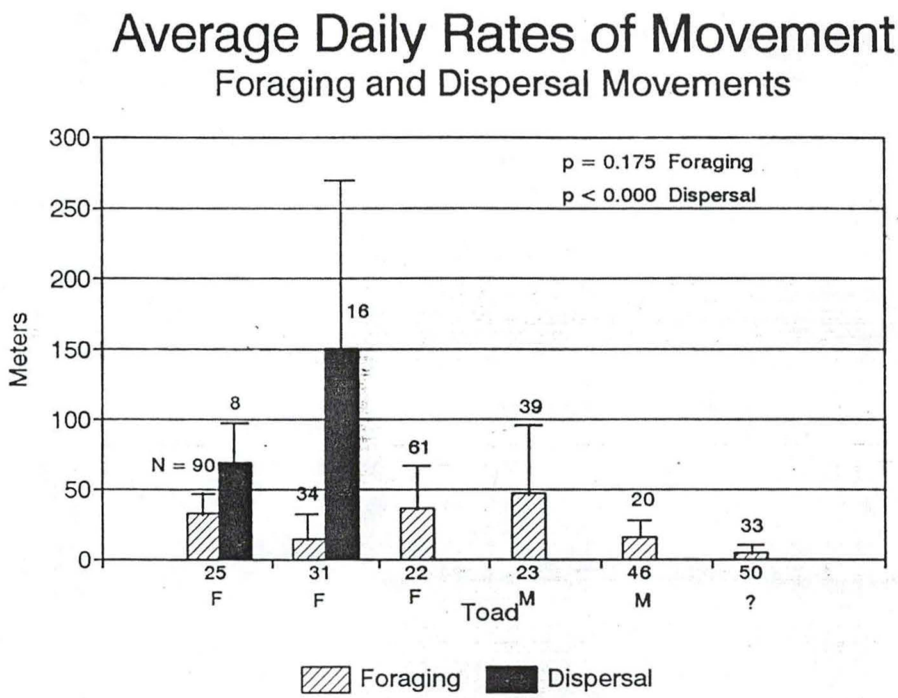


Figure 8. A comparison of average daily rates of movements between male and female toads, and between foraging and dispersal movements. Only female toads dispersed from the pond. Dispersal movements were extensive. Movements within foraging areas were small for all toads, usually 50 m or less per day.

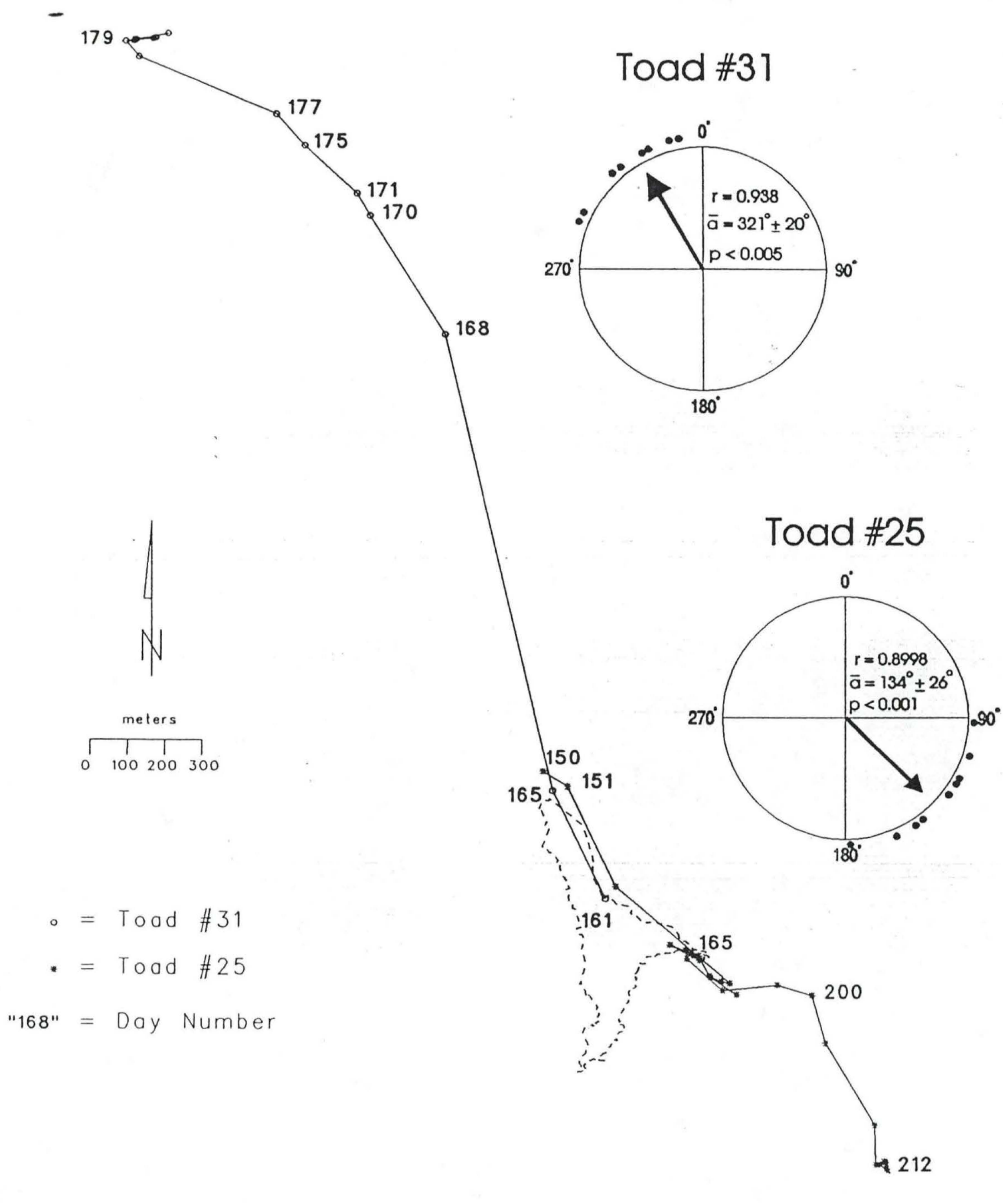


Figure 9. Movements of toads #25 and #31 at the Stamp Meadows site. The irregular polygon represents the water level for the pond on June 19. Symbols represent daily locations, and connecting lines the approximate direction of travel between relocation days. Numbers at each location are the day of year for each location. Movements of both toads are significantly linear.

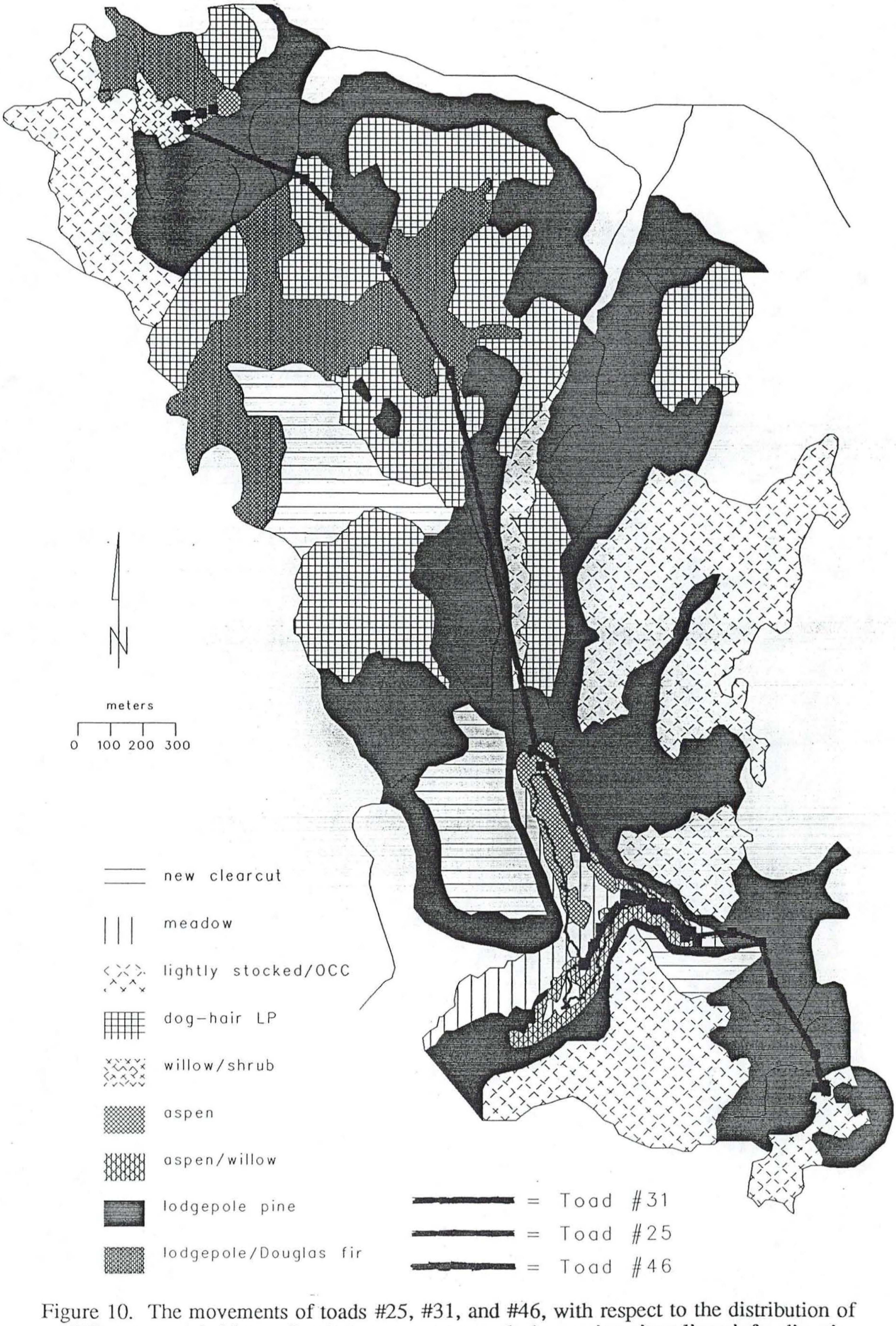


Figure 10. The movements of toads #25, #31, and #46, with respect to the distribution of different macrohabitats. Symbols represent actual observation sites; lines infer direction of movement. We often observed toads near the edges of macrohabitats. Toad #25 appeared to move around a clearcut as it traveled southeast of the pond area.

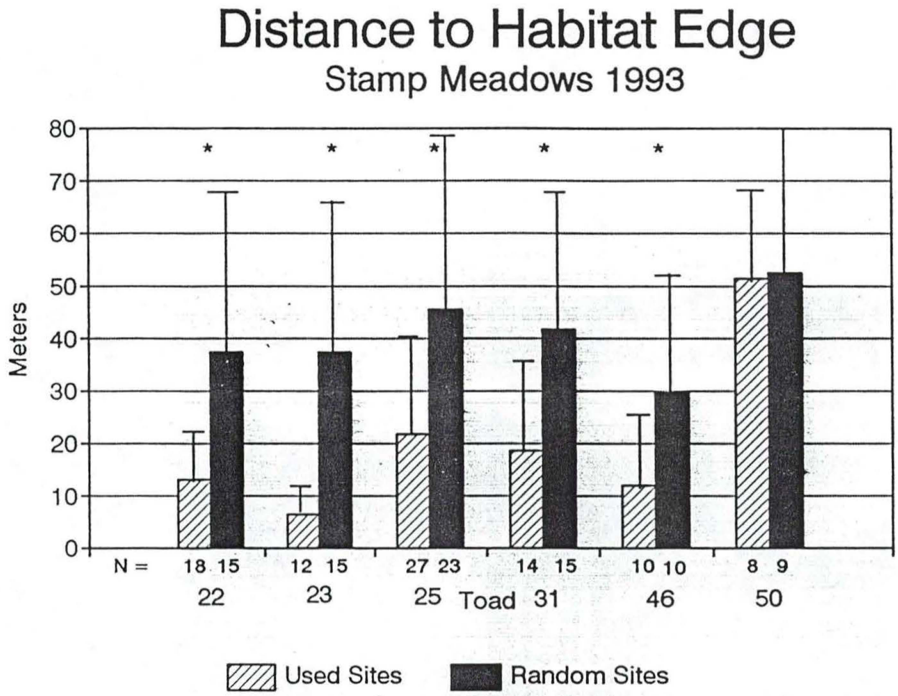


Figure 11. A comparison of the distance between the edges of macrohabitat patches and the sites used by toads, to that of patch edges and randomly selected sites. Sites used by toads were significantly closer to patch edges.

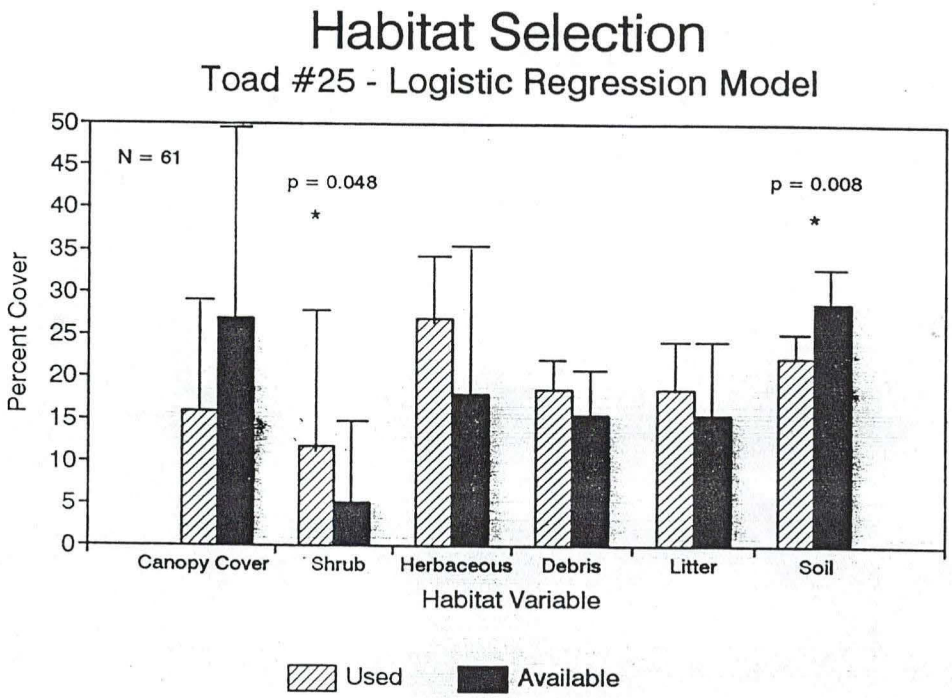


Figure 12. Results from a logistic regression model for macrohabitats used by toad #25. According to these results, toad #25 selected patches with significantly greater shrub and significantly less bare soil. This is the only individual for which logistic regression analysis provided significant results. We attribute the lack of significance for other toads to the small sample sizes for each toad.

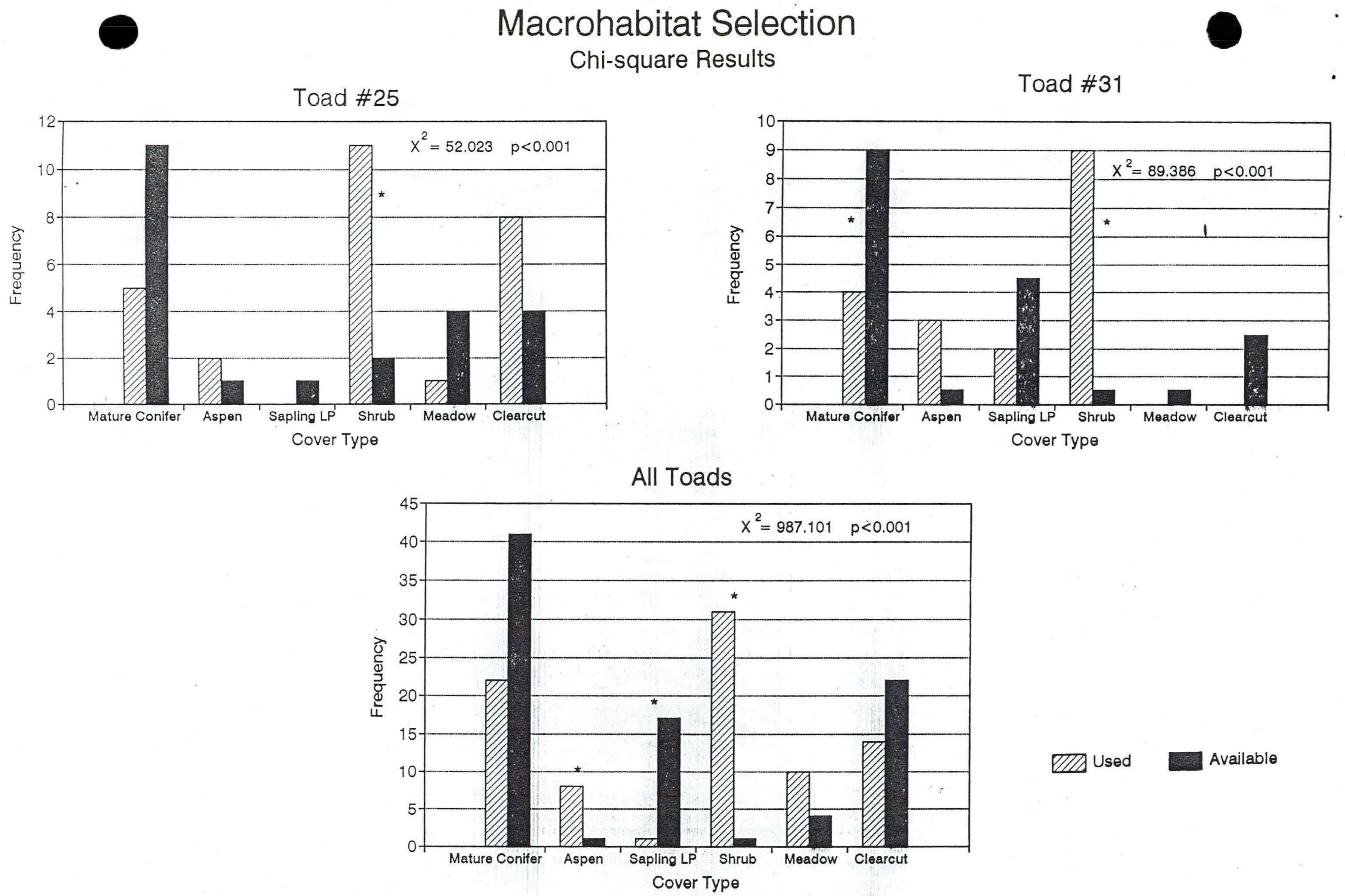


Figure 13. A comparison of macrohabitat cover types used by toads and surrounding randomly chosen sites. The top two histograms are results for toads #25 and #31, respectively, and include patches through which they dispersed. The bottom histogram are results for the pooled data of all toads at Stamp Meadows. χ^2 and p values represent overall differences; asterisks (*) indicate significant differences within a habitat category.

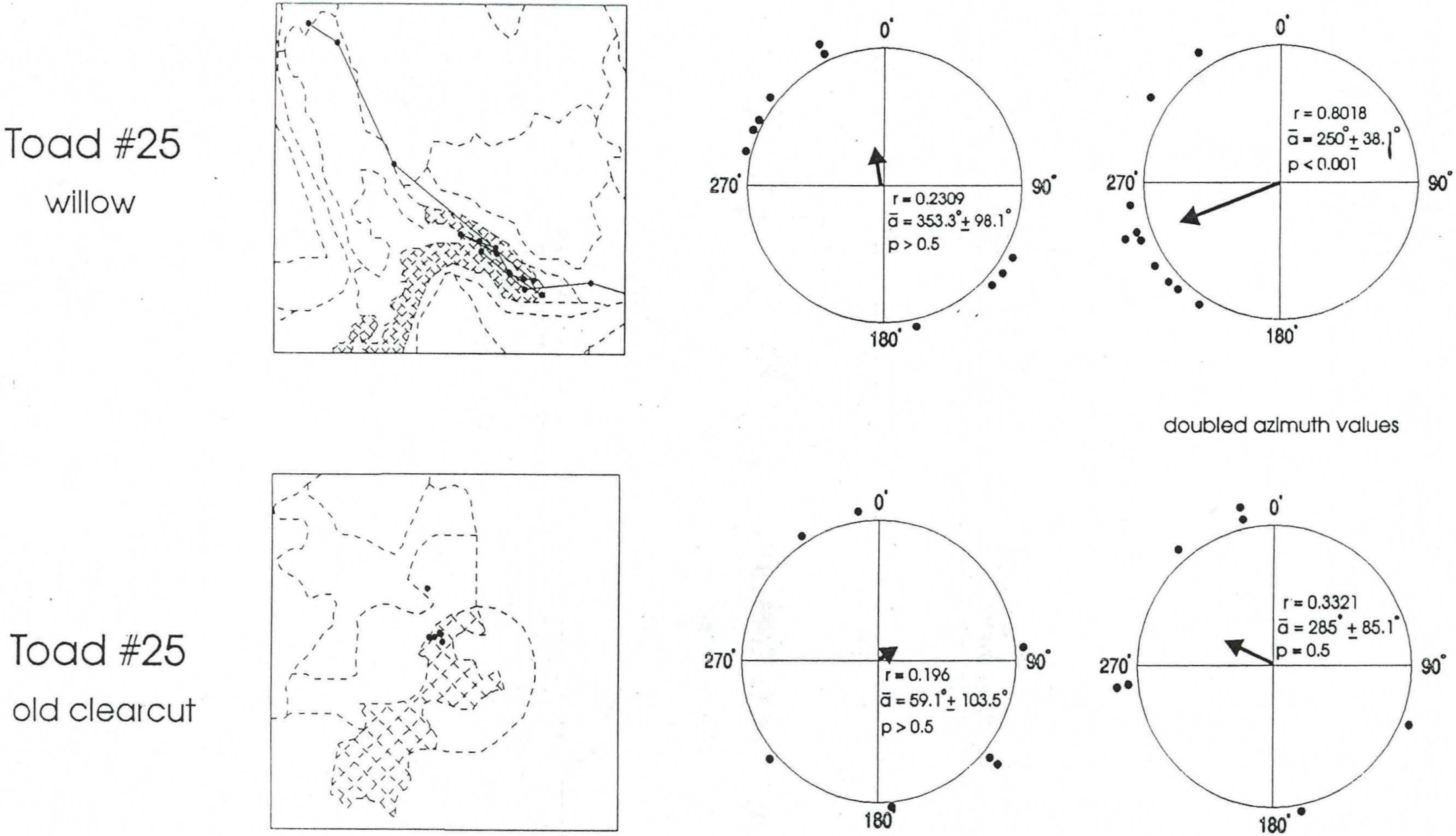
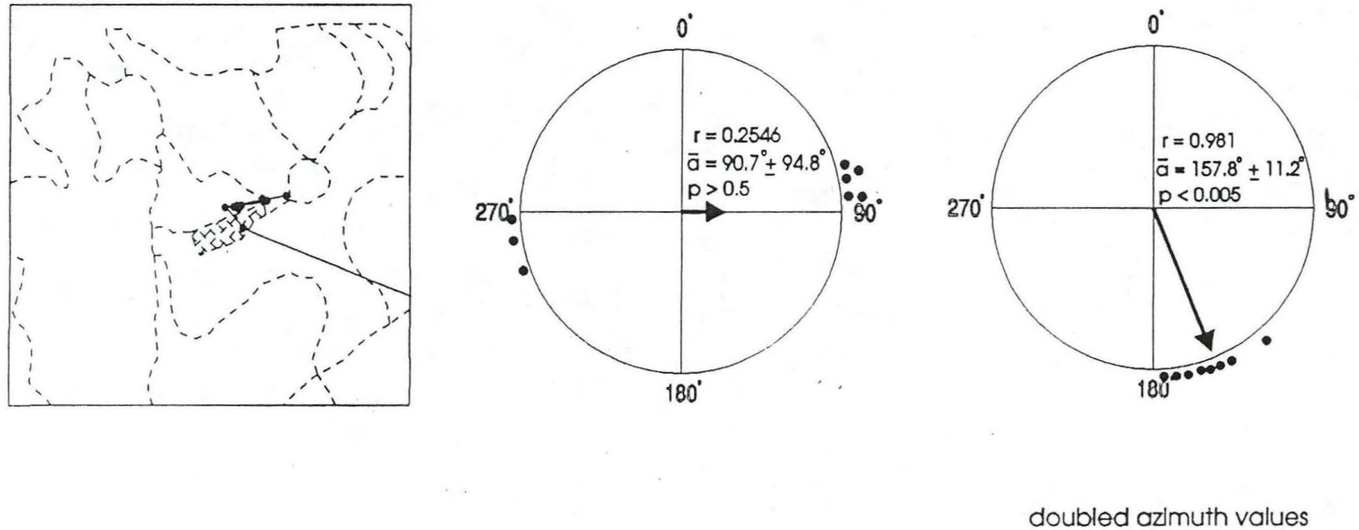


Figure 14. The influence of shrub cover on the foraging movements of toad #25. In both types of patches, the movements of this toad seemed influenced by the distribution of shrub cover. When shrub cover was abundant in the willow patch (top figure), her movements were significantly linear and reflected the shape of that patch. When this toad moved to the old clearcut (bottom figure), she was found only under scattered individual *Pinus* saplings and two slashpiles. Her movements in this patch seemed more scattered and were not significantly linear, even when the azimuth values were doubled.

Toad #31



Toad #50

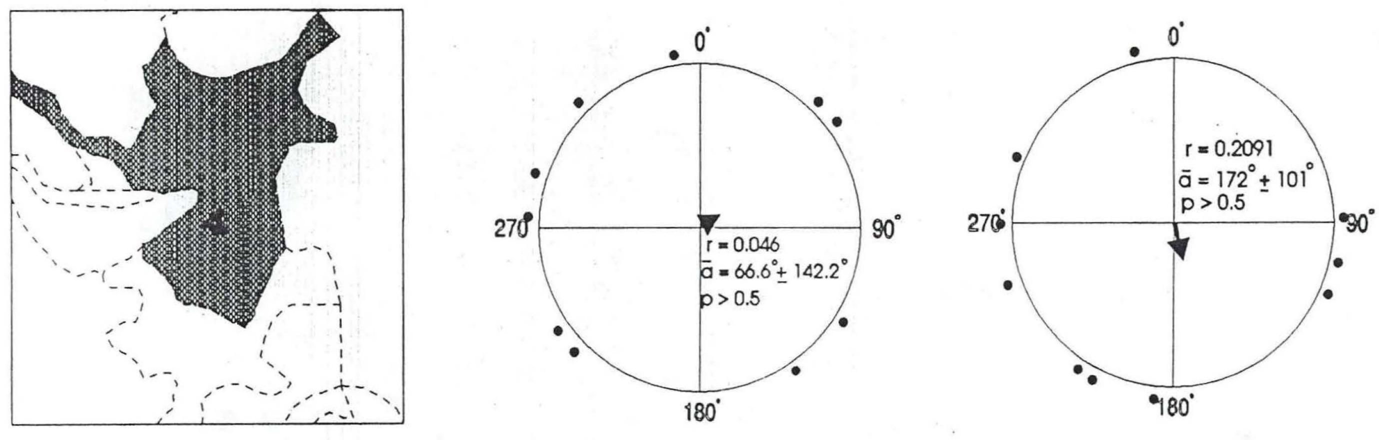


Figure 15. The influence of shrub cover on the movements of toads #31 and #50. The movements of toad #31 (top figure) were significantly linear and seemed oriented to a heavy shrub growth. Toad #50 inhabited a patch of mature conifers where canopy cover was abundant. Its movements were not significantly linear, and it moved among scattered conifer saplings and logs.

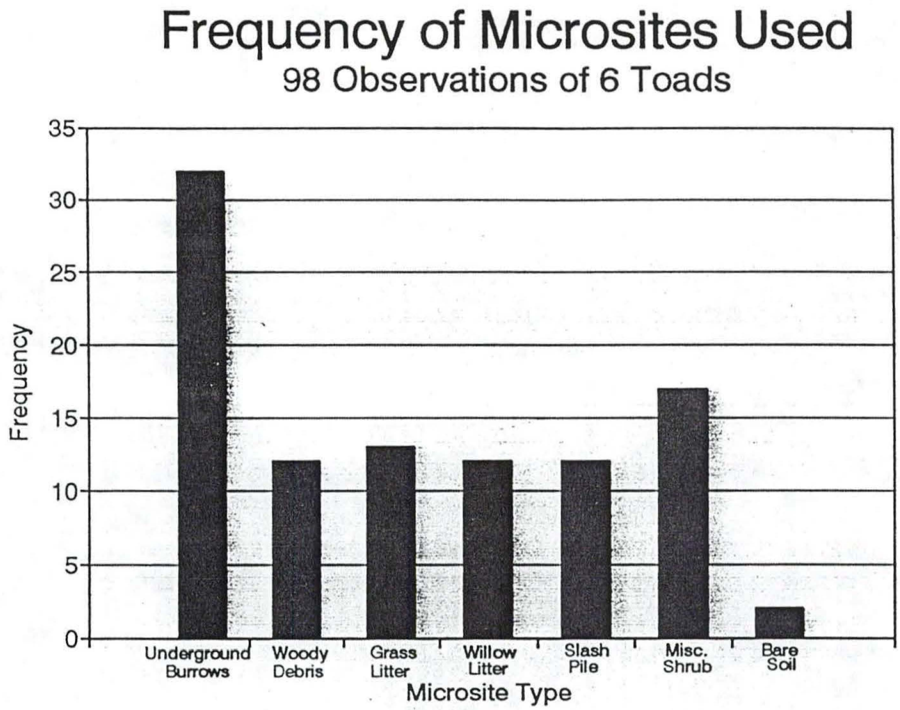


Figure 16. The types and frequency of microsites that were used by toads.

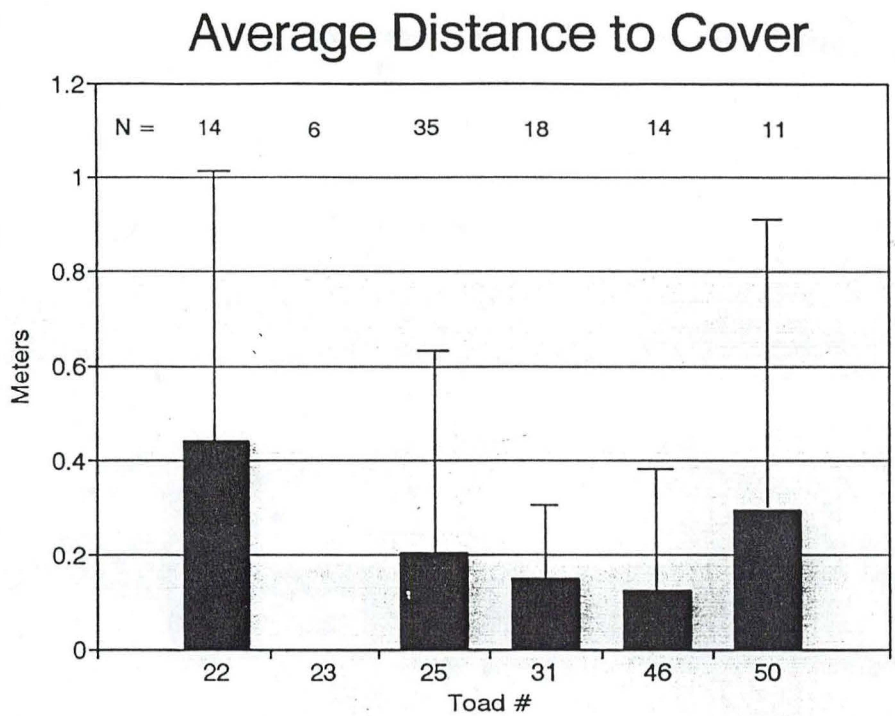


Figure 17. The average distance that we observed toads from a nearest source of cover. The value for toad #23 is 0, because she was always in the pond and used a combination of water and floating debris for cover, or when he left the pond, he was always at the entrance of a burrow or within a slashpile.

Microhabitat Selection

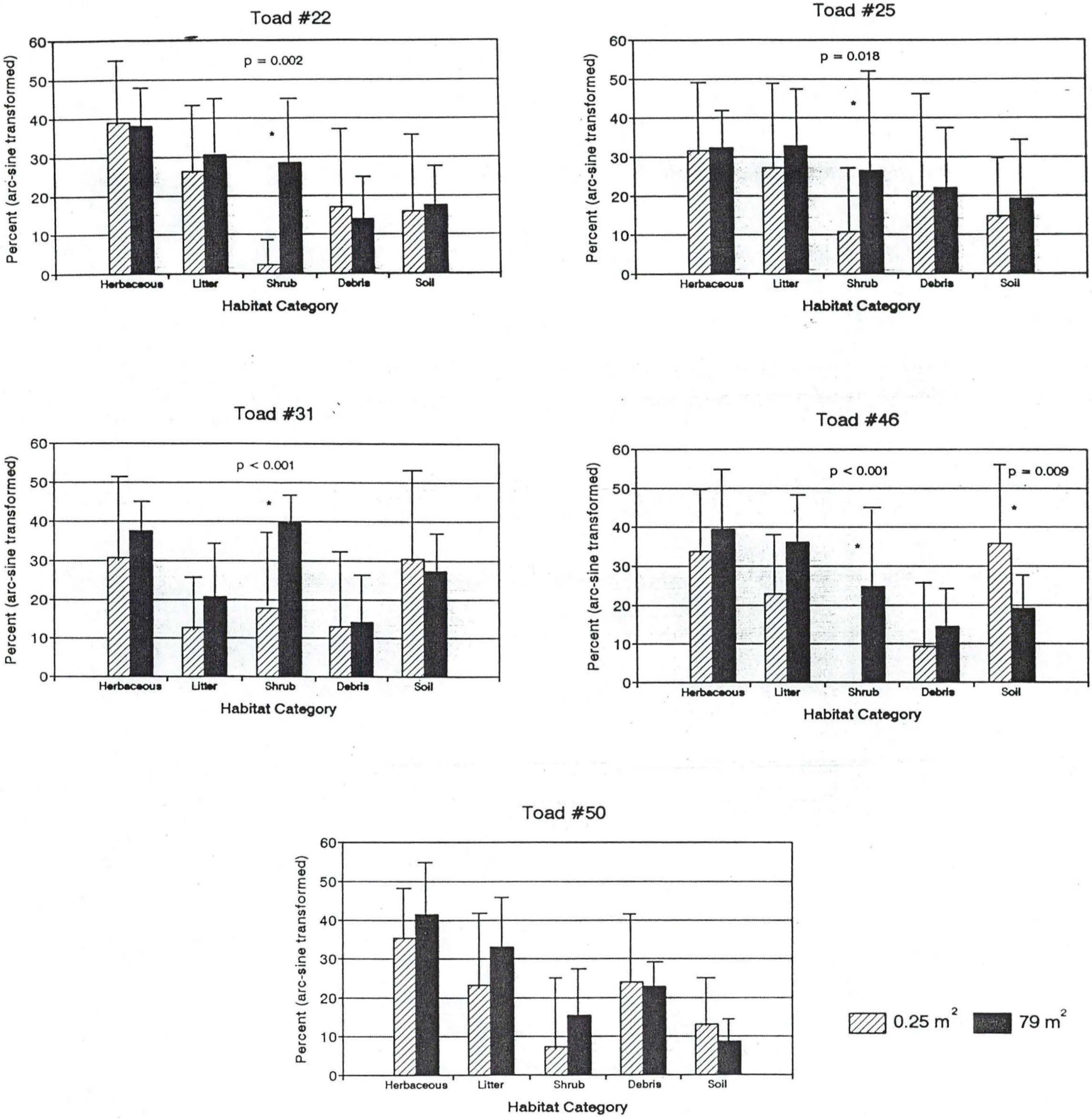


Figure 18. A comparison of the amount of cover among different habitat categories between the two scales of microhabitat. According to these results, four of these five toads selected microsites (0.25 m^2 scale) with significantly less shrub cover than was available in the larger scale (79 m^2) area. Toad #46 also selected sites with significantly greater amounts of bare soil.

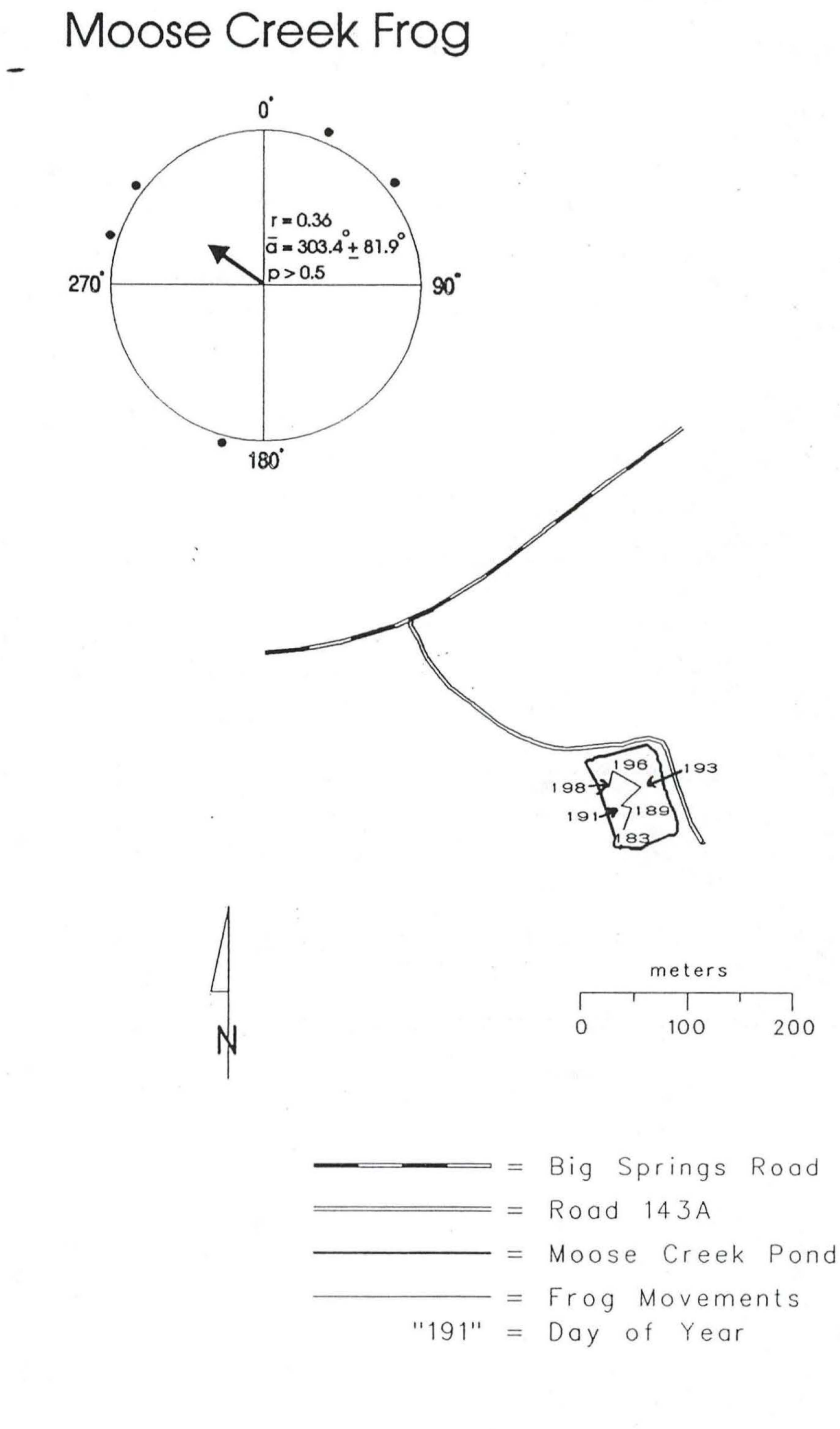


Figure 19. Movements of the frog that was telemetered in the Moose Creek pond. She never left the pond, and her movements were not significantly linear.